Prevention of thromboembolic events in surgical patients through the creation and implementation of a computerized risk assessment program

Sarah Jane Novis, BA,[a] George E. Havelka, MD,[a] Denise Ostrowski, RN,[c] Betsy Levin, MA,[c] Laurie Blum-Eisa, RN,[c] Jay B. Prystowsky, MD,[b,c] and Melina R. Kibbe, MD,[a,b,c] *Chicago, Ill*

Objectives: **Deep vein thrombosis (DVT) is a major source of postoperative morbidity and mortality and is currently a major quality improvement initiative. Mechanical and pharmacological prophylaxis is effective in preventing postoperative thromboembolic events, yet it remains underutilized in the clinical setting. Thus, the objective of this study was to develop and implement a computerized DVT risk assessment program in the electronic medical record and determine its effect on compliance with DVT prophylaxis guidelines.**

Methods: **A standardized DVT risk assessment program was developed and incorporated into the Computerized Patient Record System for all surgical patients at the Jesse Brown Veterans Affairs Medical Center. Four hundred consecutive surgical patients before and after implementation were evaluated for DVT risk, the prescription of pharmacological and mechanical DVT prophylaxis, and the development of thromboembolic events.**

Results: **With implementation of the DVT risk assessment program, the number of patients receiving the recommended pharmacological prophylaxis preoperatively more than doubled (14% to 36%) ($P < .001$), and use of sequential compression devices (SCD) increased 40% ($P < .001$). Overall, the percentage of at-risk patients receiving the recommended combined DVT prophylaxis of SCD and pharmacological prophylaxis increased nearly seven-fold (5% to 32%) ($P < .001$). The assessment also improved use of prophylaxis postoperatively, increasing SCD use by 27% ($P < .001$). With respect to DVT occurrence, there was an 80% decrease in the incidence of postoperative DVT at 30 days and a 36% decrease at 90 days; however, this did not reach statistical significance due to the low event rate.**

Conclusions: **The creation and implementation of a standardized DVT risk assessment program in the electronic medical record significantly increased use of pharmacological and mechanical DVT prophylaxis before surgery in a Veterans Affairs Medical Center setting. (J Vasc Surg 2010;51:648-54.)**

Deep vein thrombosis (DVT) is a major postoperative complication that has been estimated to occur in up to 40% of patients without prophylaxis.[1] The morbidity and mortality associated with thromboembolic events is high, with 28-day fatality rates reported as 9% for DVT and 15% for pulmonary embolism (PE).[2]

Fortunately, DVT can be largely prevented with mechanical and pharmacological prophylaxis, and multiple guidelines have been established to stratify patients based on DVT risk and have recommended appropriate prevention measures.[3-7] While these guidelines provide refined strategies for DVT risk assessment and prophylaxis, they are difficult to implement in the clinical setting and compliance is poor. Thus, DVT leading to PE remains the number one preventable cause of hospital death.[3]

Given the great mortality and cost, it is not surprising that venous thromboembolism (VTE) prevention is currently a major quality improvement initiative. In the past, many of the longstanding quality improvement initiatives, including the National Surgical Quality Improvement Program (NSQIP), have looked at the rate of VTE events mainly as an outcome measure.[8] More recently, the Joint Commission of Accreditation of Healthcare Organizations (JCAHO), the National Quality Forum, and the Surgical Care Improvement Program (SCIP) have worked to mandate VTE risk assessment and prophylaxis administration for all surgical patients. As of May 2009, VTE prevention became one of the core measures utilized by JCAHO for quality assessment.[9]

While these measures highlight the importance of VTE prophylaxis, they do not specifically address the difficulties with implementing DVT prophylaxis on a large scale — namely that DVT prophylaxis guidelines contain long lists of risk factors and complex risk stratification and prophylaxis dosing, which can be cumbersome to use in the clinical setting for every patient.[3]

The advent of electronic medical records presents an opportunity to uniformly implement DVT prophylaxis for all patients. It has been demonstrated that computer-based clinical decision support systems are among the most effective strategies for increasing adherence to DVT prophylaxis guidelines and increasing prophylaxis prescription.[10-13] Despite this, few hospitals with electronic medical records have systems in place that directly address the problem of DVT prophylaxis and work to increase compliance. Furthermore, of the systems that have been implemented,

From the Division of Vascular Surgery[a] and the Department of Surgery,[b] Northwestern University Feinberg School of Medicine and the Jesse Brown Veterans Affairs Medical Center.[c]

Competition of interest: none.

Reprint requests: Melina R. Kibbe, MD, Division of Vascular Surgery, Northwestern University, 676 N. St. Clair St., #650, Chicago, IL 60611 (e-mail: mkibbe@nmh.org).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a competition of interest.

0741-5214/$36.00

Published by Elsevier Inc. on behalf of the Society for Vascular Surgery.

doi:10.1016/j.jvs.2009.08.097

many include only electronic reminders that patients are considered at-risk for DVT, but do not outline the reasons why the patients are at high risk and do not give specific guidelines for prophylaxis or aid in dosing.[10]

In this study, we aimed to increase compliance with preoperative DVT prophylaxis administration in surgical patients through the use of an automated DVT risk assessment with order-generating capabilities. We elected to study preoperative DVT prophylaxis specifically, as this is an important component of prophylaxis that is easily missed. The concept of preoperative prophylaxis administration stems from recognition that DVT development begins perioperatively and that preoperative prophylaxis optimizes anti-thrombotic effectiveness.[14-16] Given this concept, the vast majority of studies demonstrating the efficacy of low-dose unfractionated heparin and low molecular weight heparin have included an initial dose two hours prior to surgery,[1,17,18] and the administration of preoperative prophylaxis has accordingly become the standard dosing routine at many hospitals.

We therefore hypothesized that compliance with recommended preoperative DVT prophylaxis for surgical patients can be increased by creating and implementing an automated DVT risk assessment with order-generating capabilities into the electronic medical record.

METHODS

This study consisted of three parts. First, a standardized DVT risk assessment program for the Computerized Patient Record System (CPRS) was created. Second, it was incorporated into the Jesse Brown Veterans Affairs Medical Center (VAMC) CPRS as part of the mandatory presurgical assessment completed for all surgical patients. Third, a retrospective and prospective review was performed to examine DVT prophylaxis utilization before and after implementation of the assessment. This study was approved by the Institutional Review Board of Northwestern University, Chicago, IL (Protocol #2343-003) and the Research and Development Committee of the Jesse Brown VAMC, Chicago, IL.

DVT risk stratification in this study was based on the American College of Chest Physicians' guidelines,[3] which have been the basis for recommendations by many quality improvement initiatives, including SCIP. While these guidelines do not specify pre- vs postoperative timing of prophylaxis in most cases, they were used to develop our recommended preoperative prophylaxis guidelines for the purpose of this study. The Chest guidelines stratify DVT risk based on patient age and risk factors and recommend appropriate prophylaxis based on risk category. The risk-treatment algorithm for our study is shown in Table I. The only deviation of this algorithm from the Chest guidelines is for the 'Age<40, no risk factors' category, in which the Chest guidelines recommend early ambulation only. We chose to also recommend sequential compression devices (SCD) for this category, given that it comprises a very small portion of our patient population and that we preferred to err on the side of caution. The list of common DVT risk

Table I. DVT risk assessment algorithm

Risk stratification	*Recommended prophylaxis*
Age <40, No risk factors	Ambulate early, SCD
Age <40, Risk factors present	Heparin Q12 or Lovenox, ambulate early, SCD
Age 40-60, No risk factors	Ambulate early, SCD
Age 40-60, Risk factors present	Heparin Q8 or Lovenox, ambulate early, SCD
Age >60, With or without risk factors	Heparin Q8 or Lovenox, ambulate early, SCD

DVT, Deep vein thrombosis; *SCD,* sequential compression devices; *Q12,* every 12 hours; *Q8,* every eight hours.

Table II. Risk factors for DVT

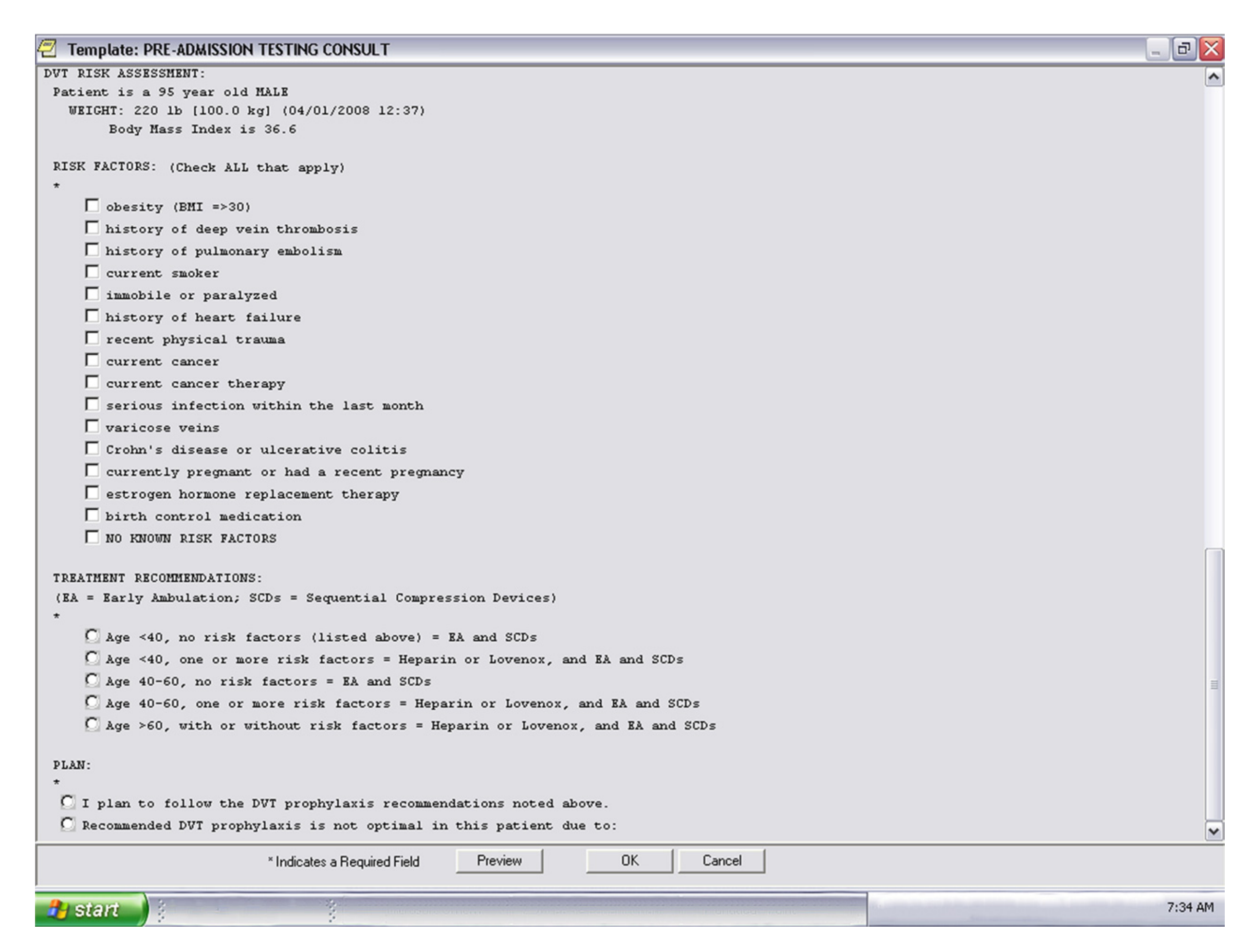
DVT risk factors
Obesity (BMI >30)
Current smoker
History of DVT
History of PE
History of heart failure
Recent physical trauma
Crohn's disease or ulcerative colitis
Current cancer
Current cancer therapy
Serious infection within the last month
Varicose veins
Immobilized before surgery
Currently pregnant or recent pregnancy
Estrogen hormone replacement therapy
Oral contraception

BMI, Body mass index; *DVT,* deep vein thrombosis; *PE,* pulmonary embolism.

factors was compiled based on a survey of multiple DVT prevention guidelines (Table II).[3-8]

Our algorithm and DVT risk factor list was incorporated into the CPRS electronic medical record at the Jesse Brown VAMC as part of the Pre-Admission Testing order set that must be completed for every surgical patient before a procedure. The DVT assessment portion of this order set included the complete list of risk factors and a risk stratification algorithm (Fig 1). Completion of this section was mandatory for submission of the Pre-Admission Testing order set. An option to opt-out of DVT prophylaxis was provided and required the physician to give a reason for this decision. For all other patients, the appropriate orders for DVT prophylaxis were automatically generated, based on the patient's risk stratification category. These orders included the correct dosing and instructions, and only required a physician's signature to become active (Fig 2).

After this DVT risk-assessment was incorporated into the electronic medical record on August 1, 2007, a chart review was completed to determine DVT prophylaxis usage and DVT incidence at the Jesse Brown VAMC. Eligible patients were required to have a surgery in the specialties of general surgery, orthopedic surgery, vascular surgery, thoracic surgery, urology, or otolaryngology, as these were the


Template: PRE-ADMISSION TESTING CONSULT

DVT RISK ASSESSMENT:
Patient is a 95 year old MALE
WEIGHT: 220 lb [100.0 kg] (04/01/2008 12:37)
Body Mass Index is 36.6

RISK FACTORS: (Check ALL that apply)
*
- obesity (BMI =>30)
- history of deep vein thrombosis
- history of pulmonary embolism
- current smoker
- immobile or paralyzed
- history of heart failure
- recent physical trauma
- current cancer
- current cancer therapy
- serious infection within the last month
- varicose veins
- Crohn's disease or ulcerative colitis
- currently pregnant or had a recent pregnancy
- estrogen hormone replacement therapy
- birth control medication
- NO KNOWN RISK FACTORS

TREATMENT RECOMMENDATIONS:
(EA = Early Ambulation; SCDs = Sequential Compression Devices)
*
- Age <40, no risk factors (listed above) = EA and SCDs
- Age <40, one or more risk factors = Heparin or Lovenox, and EA and SCDs
- Age 40-60, no risk factors = EA and SCDs
- Age 40-60, one or more risk factors = Heparin or Lovenox, and EA and SCDs
- Age >60, with or without risk factors = Heparin or Lovenox, and EA and SCDs

PLAN:
*
- I plan to follow the DVT prophylaxis recommendations noted above.
- Recommended DVT prophylaxis is not optimal in this patient due to:

* Indicates a Required Field   Preview   OK   Cancel

start   7:34 AM

Fig 1. Screenshot of the electronic DVT Risk Assessment which is part of the mandatory Pre-Admission Testing that must be completed for all patients undergoing surgery preoperatively. *DVT,* Deep vein thrombosis.

services that completed the Pre-Admission Testing order set. Patients were also required to have at least a 24-hour hospital stay from the time of surgery in order to assess for the administration of postoperative DVT prophylaxis and the development of thromboembolic events while an inpatient. Follow-up data were collected to determine the 30-, 60-, and 90-day rates of postoperative PE and upper and lower extremity DVT. DVT was diagnosed by duplex ultrasound, and PE was diagnosed by spiral computed tomography scan or high probability ventilation/perfusion scan. Data was also collected on postoperative SCD and pharmacological prophylaxis ordering based on a review of orders in the electronic medical record. Blood product administration was recorded to determine if patients met the criteria for postoperative bleed, as defined by the National Surgical Quality Improvement Program guidelines to be the transfusion of more than four units of blood within the 72 hours postoperation.[19] Retrospective review of medical records was performed for 400 consecutive eligible patients preceding implementation of the algorithm from March 2007 until July 2007. After implementation of the algorithm, the medical records of an additional 400 consecutive eligible patients were reviewed from September 2007 to March 2008. Patients for whom the physician opted-out of DVT prophylaxis were not included in the analysis. Patients undergoing surgery during the month of August were also excluded, as the Pre-Admission Testing for many of these patients had been completed before implementation of the DVT portion of the order set.

For statistical analysis, a two-tailed *t* test was used for continuous variables and a two-tailed Fisher's exact test was used for categorical data. A *P* value of <0.05 was considered statistically significant.

RESULTS

Surgical patients included in this study were on average 64 years of age (range, 23 to 97 years of age) and had 1.7 risk factors for VTE (range, 0 to 7; Table III). Of this population, 41% were current smokers, and the average body mass index (BMI) was 28, with 30% having a BMI >30. Thirty-four percent of patients had cancer at the time of surgery, of which 53% was adenocarcinoma. The number of risk factors as well as the prevalence of any single risk factor did not differ significantly between the pre- and

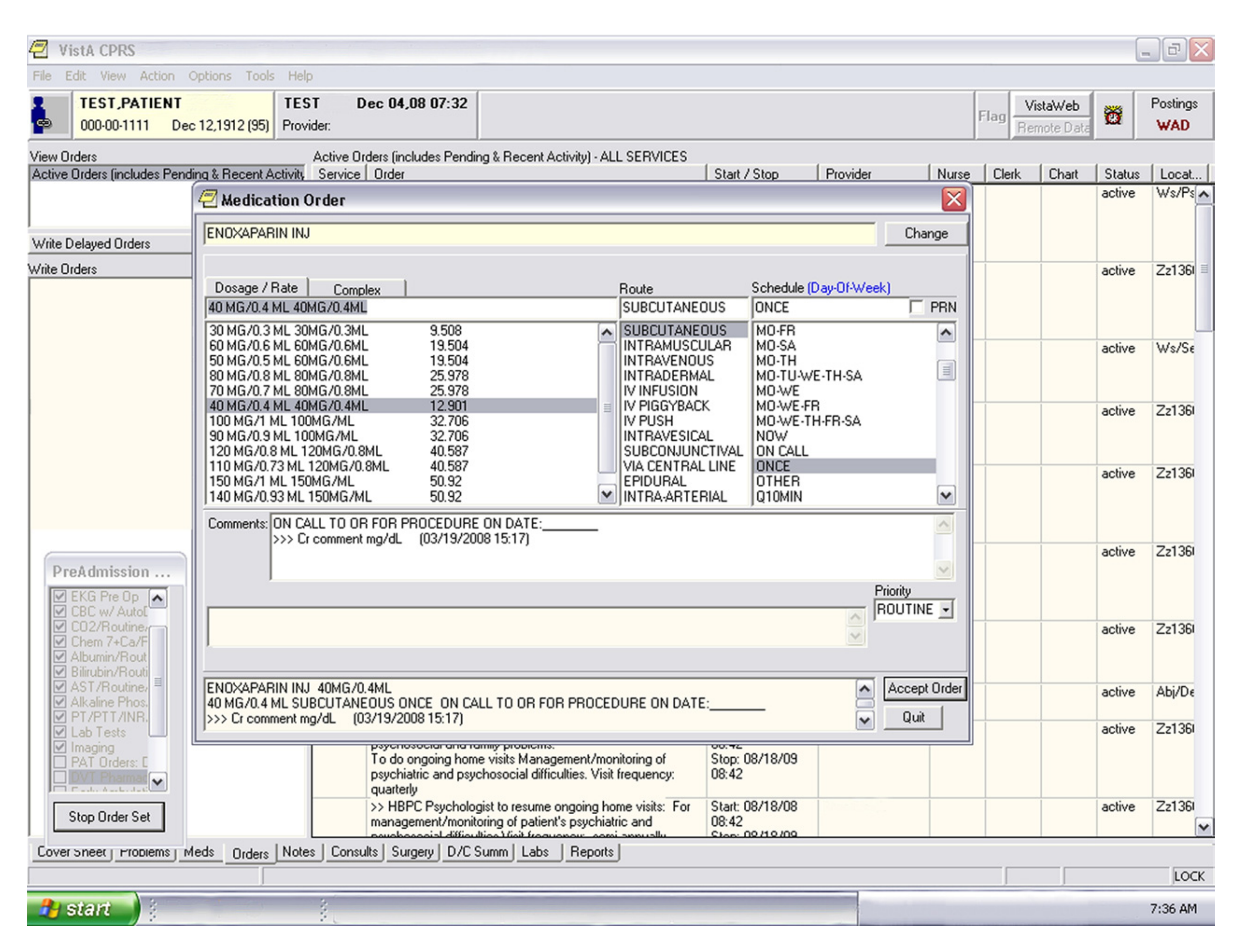


Fig 2. Screenshot of automatic orders generated by the DVT risk assessment program based on the different risk categories. *DVT,* Deep vein thrombosis.

post-implementation populations (Table III). The two populations also did not differ significantly by surgical subspecialty performing the operations (Table IV).

Analysis of the pre-implementation data showed that 22% (84/389) of patients had pharmacological prophylaxis ordered, but 37% (31/84) of these orders were cancelled more than 12 hours before the operation, making the medication non-therapeutic at the time of surgery. This leaves 14% (53/389) of patients actually receiving the recommended pharmacological prophylaxis. Preoperative SCD were ordered for 54% (215/400) of patients. However, only 5% (18/389) of patients received the recommended combination of both SCD and medication. Of the 400 pre-implementation patients, only 11 did not qualify for pharmacological prophylaxis (≤60, no risk factors) and were not included in this analysis.

After implementation of the DVT risk assessment program, 40% (151/377) of eligible patients had pharmacological prophylaxis ordered, and of these orders only 9% (14/151) were cancelled more than 12 hours before the operation, meaning that 36% (137/377) of patients actually received the recommended pharmacological prophylaxis. Preoperative SCD were ordered for 75% (301/400) of patients. Thus, 32% (119/377) of patients received the recommended combination of both SCD and medication. Of the 400 post-implementation patients, 23 did not qualify for pharmacological prophylaxis (≤60, no risk factors) and were not included in this analysis.

Comparison of the pre- and post-implementation patient populations revealed that prescription of pharmacological prophylaxis increased by 86% ($P < .001$). Inappropriate cancellation of orders more than 12 hours before surgery decreased by 75% ($P < .001$) meaning that there was a 167% increase in the number of patients actually receiving pharmacological prophylaxis ($P < .001$). SCD use increased by 40% ($P < .001$). Overall, there was nearly a seven-fold increase in the number of patients receiving both SCD and medication, with rates increasing from 5% to 32% ($P < .001$).

After implementation of the preoperative order set, there was also an increase in postoperative DVT prophylaxis ordering, possibly signifying an indirect effect of the study. After implementation, the rate of postoperative SCD ordering increased from 50% to 63% ($P < .001$). There was

Table III. Patient demographics

	Pre-implementation n (%)	*Post-implementation n (%)*	*All patients n (%)*
Number of patients	400	400	800
Male (%)	393 (98%)	392 (98%)	785 (98%)
Female (%)	7 (2%)	8 (2%)	15 (2%)
Mean age (years)	64	64	64
Mean number of risk factors*	1.7	1.7	1.7
Age >60, with or without risk factors	234 (59%)	227 (57%)	461 (58%)
Age 40-60, risk factors present	144 (36%)	148 (37%)	292 (37%)
Age 40-60, no risk factors	8 (2%)	22 (6%)	30 (4%)
Age <40, risk factors present	11 (3%)	2 (1%)	13 (2%)
Age <40, no risk factors	3 (1%)	1 (<1%)	4 (1%)
Mean BMI	27	28	28
Obesity (BMI >30)	121 (30%)	122 (31%)	243 (30%)
Current smoker	159 (40%)	165 (41%)	324 (41%)
Current cancer	136 (34%)	139 (35%)	275 (34%)
Adenocarcinoma	68 (17%)	77 (19%)	145 (18%)
History heart failure	49 (12%)	39 (10%)	88 (11%)
Serious infection in last month	35 (9%)	32 (8%)	67 (8%)
Immobilized before surgery (>1 day)	33 (8%)	33 (8%)	66 (8%)
Current chemotherapy	13 (3%)	17 (4%)	30 (4%)
Limb trauma	17 (4%)	10 (3%)	27 (3%)
History DVT	13 (3%)	9 (2%)	22 (3%)
History PE	6 (2%)	9 (2%)	15 (2%)
Crohn's or ulcerative colitis	3 (1%)	2 (1%)	5 (1%)
Varicose veins	3 (1%)	1 (<1%)	4 (1%)
Recent major trauma	0 (0%)	0 (0%)	0 (0%)

BMI, Body mass index; *DVT,* deep vein thrombosis; *PE,* pulmonary embolism.
*Excludes age as a risk factor.

Table IV. Population breakdown by surgical subspecialty

Subspecialty	*Pre-implementation study population (%)*	*Post-implementation study population (%)*
Urology	27%	22%
General surgery	22%	24%
Orthopedic surgery	21%	23%
Vascular surgery	17%	19%
Thoracic surgery	8%	5%
Otolaryngology	5%	7%

also a trend toward increase in postoperative pharmacological prophylaxis ordering from 63% to 69% ($P < .27$; NS). This gives a 53% increase in the number of patients receiving both SCD and medication, increasing from 32% to 49% ($P < .001$).

Despite the increase in preoperative prophylaxis administration, there was no significant change in postoperative bleeds, with the rate of confirmed bleeds actually decreasing from 4% to 3% after implementation of the risk assessment ($P < .34$; NS). Of the patients who experienced bleeds, there was no change in the number that received preoperative pharmacological prophylaxis, with 18% (three of 17 total bleeds) before implementation of the assessment and 18% (two of 11 total bleeds) after implementation of the assessment receiving preoperative pharmacological prophylaxis prior to their bleeding event.

Over the course of the study, there was a trend toward decreased DVT events. The 30-, 60-, and 90-day DVT rates prior to implementation were 1.5%, 1.8%, and 2.0% respectively. After implementation, the 30-, 60-, and 90-day DVT rates were 0.3%, 0.5%, 1.3% respectively. This represents an overall 80% decrease in the 30-day rate of DVT and a 36% decrease in the 90-day rate of DVT, but did not reach statistical significance given that this study was not powered to detect a change with this low of an event rate ($P < .12$, $P < .58$ respectively). There were no confirmed PE events at 90 days postoperation in this study population.

Physicians were given the opportunity to opt-out of DVT prophylaxis and the reason for this decision was collected for the purpose of the study. Of the 42 patients for whom the opt-out option was selected, the major reason cited was "active bleeding" in 16 cases. Other reasons included "no DVT prophylaxis needed according to my clinical judgment" (10 cases), "renal failure" (three cases), and "other reason" (13 cases). There was one DVT event at 62 days postoperatively in this group, giving a 90-day DVT rate of 2% for patients in which the opt-out option was selected.

DISCUSSION

Creation and implementation of an automated DVT risk assessment tool into the CPRS at the Jesse Brown VAMC led to an increase in the administration of preoperative as well as postoperative DVT prophylaxis. This study complements the findings of previous automated DVT reminder systems by addressing some of the barriers to compliance noted by these studies. Tooher et al had noted that any intervention to increase DVT prophylaxis would

need to aid in both determining patient DVT risk and assist in correct prophylaxis prescribing.[10] Many of the previous studies have employed strategies involving electronic reminders for physicians to prescribe DVT prophylaxis, with limited information regarding patient risk assessment and recommended prophylaxis dosing. For example, in Kucher et al, DVT risk was automatically calculated by the computer system, and reminders were generated only for patients determined by the computer algorithm to be at high risk for DVT.[11] The present study approached the problem of patient risk by considering all surgical patients to be at risk for DVT. Physicians then performed individualized risk-assessment for each patient within a computerized framework stemming from evidence-based clinical guidelines. This approach allowed for clinical judgment and knowledge of patient history to determine risk factors, as some risk factors may never have been entered into the electronic medical record or may not be coded as diagnoses. This study also went beyond previous studies in addressing the problem of prophylaxis dosing and administration, as risk-stratified prophylaxis information was provided, and guideline-specific orders were automatically generated, requiring only a physician's signature to become active.

The assessment of risk factors in this population further emphasized the importance of DVT risk assessment in all surgical patients. Surgery alone is a risk factor for DVT, as is increasing age.[1] In this population, the average age was 64 years, putting the majority of patients into the highest risk group based on age alone. This DVT risk is further augmented by other conditions and comorbidities which abounded in the study population, with an average of 1.7 additional risk factors per patient.

Even with the nearly seven-fold increase in administration of our recommended prophylaxis regimen, the overall rate of full compliance with our recommended preoperative prophylaxis remained low. We must acknowledge that the recommendations for preoperative DVT prophylaxis applied in this study are much more stringent than the DVT prophylaxis guidelines used by many of the quality improvement initiatives. For example, SCIP guidelines only require that the eligible patient receive pharmacologic prophylaxis with or without SCD any time within 24 hours before to 24 hours after surgery,[20] although this large window allows for a great deal of variation in prophylaxis regimens. It should be noted that compliance with the SCIP guidelines was 100% at the Jesse Brown VAMC during the time of data collection for this study. Despite this, we did not consider it acceptable for many surgical patients to be without SCD or preoperative prophylaxis, and accordingly utilized stricter guidelines in this study.

There were also multiple patients in this study for which the physician did not choose to opt-out of prophylaxis but for which inadequate or no prophylaxis was ordered. This disparity can mostly be attributed to differing surgeon or subspecialty-specific preferences for DVT prophylaxis. For example, at the Jesse Brown VAMC, the Department of Orthopedic Surgery has a DVT prophylaxis protocol for total hip arthroplasty that does not include preoperative medication. In these cases, the ordering physicians signed the automatically generated orders for preoperative SCD but declined the order for medication. While we acknowledge that some subspecialties have their own DVT prophylaxis guidelines that are procedure-specific, this certainly does not eradicate the need for the order set in subspecialty surgeries. Rather, this allows the order set to act as a reminder of the importance of appropriate DVT risk-assessment and prophylaxis, and physicians are encouraged to prescribe prophylaxis based on subspecialty guidelines.

In some cases, lack of knowledge regarding the need for preoperative DVT prophylaxis may also have played a role in the low rate of preoperative prophylaxis, given that the vast majority of pre-admission testing orders are completed by surgical interns and residents. This highlights the educational value of the order set. Previous studies have indicated that computer-based decision support systems can improve knowledge of preventative care and medication dosing.[21] The educational component of this study is illustrated by the 75% decrease in the number of preoperative DVT prophylaxis orders inappropriately cancelled more than 12 hours before surgery. The computerized DVT risk assessment did not directly prevent cancellation of orders, and thus this decrease is likely due to house staff becoming increasingly aware of the need for preoperative DVT prophylaxis and gaining familiarity with DVT risk factors and treatment guidelines by going through the computerized risk-assessment multiple times. The need to educate continuously changing house staff is a major way in which we are working to improve DVT prophylaxis compliance at our institution, and the effect of computerized order sets on house staff education is certainly of great importance at a major teaching hospital and presents an avenue for further investigation.

The educational effect of this study may also have played a role in the increase of postoperative DVT prophylaxis seen in our analysis. Although there was no direct intervention, an increase in postoperative SCD ordering and a trend toward increase in postoperative medication ordering was seen after implementation of the order set. This can possibly be explained by patients arriving from surgery on the inpatient floors already wearing SCD boots, making it simple for physicians to simply renew the order. It may also be secondary to the expired orders for SCD and medication showing up in the computer, serving as a reminder for physicians to continue prophylaxis postoperatively.

In addition to increasing DVT prophylaxis both pre- and postoperatively, the DVT order set also led to a trend toward decreased incidence of DVT. After implementation of the order set, the rate of DVT decreased by 80% at 30 days and 36% at 90 days. While this study was not powered to detect a change with such a low event rate, it is an encouraging finding and is consistent with the Kucher et al study, which demonstrated that electronic medical record interventions could significantly decrease the rate of DVT.[11] This highlights the need to continue data collection on DVT occurrence with the new order set in order to determine its efficacy in reducing DVT and PE events.

While a trend toward decreasing DVT events was noted, we did not find any corresponding increase in postoperative bleeds secondary to the preoperative prophylaxis. There was actually a small decrease in the rate of bleeds after implementation of the order set, which can likely be attributed to the "opt out" option in the order set. Despite removal of some of the patients at higher risk for bleeding from our analysis, we expected to see an increase in the proportion of postoperative bleed patients who had received preoperative heparinization if the medication was, in fact, the cause of the bleeds. Instead, we found that 18% of postoperative bleed patients in both groups received heparinization prior to surgery, suggesting that the increased rate of preoperative DVT prophylaxis did not lead to an increase in the rate of bleeds.

While the increase in DVT prophylaxis usage and trend toward decreasing rates of DVT found in this study are promising, there are limitations. First, this study included only 800 patients, and was therefore not powered to detect a change in the rate of DVT. Second, it only provides a limited sample of the first seven months of usage after implementation of the assessment, and usage patterns may differ over a longer time course. Third, we acknowledge limited detection of postoperative DVT occurrences secondary to inconsistent patient follow-up in clinic and to patients receiving care outside of the VA system. While this may have led to an artificially low DVT rate, it was unchanged throughout the study period and does not likely explain the trend toward decreasing DVT noted in this study. Finally, we acknowledge that the DVT prophylaxis guidelines used in this study were not specific to any subspecialty, but were intended to be broad in order to cover as many surgical patients as possible and allow for clinical judgment to tailor prophylaxis ordering to subspecialty and institutional protocols.

CONCLUSION

In summary, this study demonstrated that implementation of a computerized DVT risk assessment tool with automatic order-generating capabilities led to an increase in appropriate mechanical and pharmacological DVT prophylaxis orders for surgical patients. This order set was successful in its goal of increasing compliance with evidence-based clinical guidelines for DVT prophylaxis. These results suggest that other hospitals utilizing electronic medical records may want to consider implementing similar systems in order to increase DVT prophylaxis utilization.

AUTHOR CONTRIBUTIONS

Conception and design: SN, DO, BL, LB, JP, MK
Analysis and interpretation: SN, GH, DO, MK
Data collection: SN, GH, DO, MK
Writing the article: SN, MK
Critical revision of the article: SN, GH, DO, BL, LB, JP, MK
Final approval of the article: SN, GH, DO, BL, LB, JP, MK
Statistical analysis: SN, MK
Obtained funding: N/A
Overall responsibility: MK

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Submitted Jul 21, 2009; accepted Aug 31, 2009.